

# The history of iron in China in the Ming Dynasty: An overview

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## Author Biography

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## Abstract

The Ming Dynasty proves to be an integral stage for Chinese iron industry's development. The rapid advancements of iron productivity and technologies during this time period penetrated the society, ranging from national power to culture and environment. However, because of the complexity in Ming's iron industry's developments and wide impacts on various social aspects, most existing studies remain at the level of case studies or focus on only one specific aspect. To offer a concise and comprehensive overview of Ming Dynasty's iron industry development and its multi-dimensional influence on the society, this literature review presents holistic insights into Chinese iron industry's evolution and heritage as well as advancements and challenges. Through the synthesis of important historical records and statistics, this literature review, from five different social aspects, shows Ming's iron industry's integral role in national power, culture, and technological developments. Nevertheless, the environmental impact proved to be a serious problem for the Ming society.

*Keywords: Natural Resource History, Ming Dynasty, Iron Industry, Ancient Heavy Industry, Iron Production, Iron Trade, Historical Records, Archaeological Discoveries.*

## Introduction

Chinese iron production developed at an unprecedented pace in the Ming Dynasty, with the world-leading large production scale, high yields, and advanced technologies of its time. According to statistics provided by the Chinese Academy of Social Sciences, iron production in the Ming Dynasty hit the peak compared to past dynasties, having 8.9 times the iron production in the Tang Dynasty (one prosperous dynasty prior to the Ming Dynasty) and ahead of contemporary Europe (Zhang, 2008).

Despite the unprecedented prosperity of the iron industry, however, few studies offer comprehensive insights into its full historical development and multi-dimensional social influences. Overall, existing literature ranges from historical records to contemporary archaeological case studies, which offer scattered revelations on the development of the Ming Dynasty's iron industry. Aiming to give a comprehensive review on this subject, this literature review analyzes diverse historical records and archaeological evidence. Through discussion of the five different dimensions, respectively evolution of iron's practical uses, influences on national power, cultural significance, technological advancements, and environmental challenges, this literature review holistically reveals the Ming Dynasty's iron industry's developments, influences, and challenges.

## Methodology

This literature review is based mainly on two types of studies: historical records in the Ming Dynasty and their relevant modern analyses, and modern archeological discoveries. For the ancient historical records, the iron industry-specific book *Tie Ye Zhi*, the chronicle *Ming Shi Lu*, and the law code *Da Ming Hui Dian* are selected for analysis. Meanwhile, this literature review refers to some modern interpretations of these ancient records; such articles were accessed with keywords such as those books' names, "the Ming Dynasty," "iron," and "heavy industry." Ultimately, this literature review also analyzes archaeological case studies as evidence, including image evidence of the discovered artifacts and archaeological deductions about the iron smelting and production techniques. The keywords include "the Ming Dynasty," "ironware production," "iron smelting," "iron trade," "state-owned ironworks," and "private ironworks."

## Evolution of Iron's Practical Uses

In the Ming Dynasty, iron, an ancient natural resource, experienced a shift in practical usage in Chinese society. Inherited from past dynasties like the Tang and the Song, at the beginning of the Ming Dynasty the government made state-owned production the standard in the iron industry (Hartwell, 1962). The state-owned ironworks primarily served to make weapons for armies. The famous Zunhua ironworks in Hebei Province was a typical example of state-owned ironworks that contributed to weapon production (Huang, 2022; Chen et al., 2016). Later, when private iron workshops developed, civilian uses of iron started emerging, not limited to weapon production anymore but involving cheap everyday tools like axles, nails, pots, and pans (Li et al., 2023; Huang, 2022; Reeves et al., 2022). For instance, the iron Guang pans, named after their place of production Guangdong Province, were famous for their superior quality and were sold to people all over the country (Zhang, 2008). Hence, in the Ming Dynasty, the practical uses of iron went through a process of diversification and more deeply penetrated civil life.

## Influences on National Power

As the iron industry rapidly developed in the Ming Dynasty, it experienced wide-ranging developments on the national level, ranging from economics to military and politics. In turn, the iron industry's developments also brought comprehensive influences on Ming's national power.

The iron industry's greatest influence on Ming's national power might be on its economy, with the contribution to economic prosperity and the primitive development of capitalism. Such effects were largely brought by the emerging private-owned ironworks. Different from the previous pattern with state-owned ironworks as the majority, in the Ming Dynasty, private ironworks emerged and even started taking dominance in the iron industry. Private ironworks provided more flexible and individualized production to compete with their state-owned counterparts (Yang, 2004). For such strengths, private ironworks were popular in the domestic market. In fact, large-scale private ironworks soon surpassed the state-owned ironworks with high efficiencies of the independent artisans in

private iron workshops. According to the chronicle Ming Shi Lu, during Jiajing's reign, the private ironworks' iron production in Guangdong province alone had hit 13,820 tons, more than the sum of all the state-owned ironworks' iron production at the beginning of the Ming Dynasty (Huang et al., 2016). Another significant economic influence of Ming's iron industry was that it contributed to China's early development of capitalism. Believed to be one of the initial emergences of the Chinese capital economy, Ming's iron industry had the effect of compounding the government's fortune, counterintuitive to the government's previous concerns (Yang, 2004). In fact, according to the administrative code written by the Ming government, Da Ming Hui Dian, governments filled the national treasury with enough iron resources and gained even more revenues from the taxation paid by private ironworks (Shen & Zhao, 2002; Reeves et al., 2022). This laid an important foundation for the Ming Dynasty's roughly 300-year-long political control over the vast Chinese territory.

Iron production in this period also contributed greatly to the national military force. In fact, the Ming government's one initial purpose in establishing ironworks was to confront the remnants of its Mongolian enemies (Yan, 2010; Li, 2023; Hucker, 1978). Iron, as the important raw material for weapons, largely strengthened armies' fighting force. For instance, the prevalent use of iron tubular firearms and iron armour was regarded as one essential ingredient to conquer enemies (Zhang, 2006; Andrade, 2017). The typical iron firearms in the Ming Dynasty were various cannons, as shown in the photos below. In fact, iron production transited Ming's national defense from the cold weapon era to the stronger firearms era, enabling more efficient military actions (Duan, 2018).

Figure 1  
Cannon relics in the Museum of Huailai County



Note. Photos by Huailai County Tourism Office, 2022; artifacts located at the Museum of Huailai County, Zhangjiakou City from Hebei Province.

Along with the economic and military strengthening effects, advanced iron production largely enhanced Ming's overall political power. One of the most significant political influences is on Ming's international contacts with foreign countries. In the Ming Dynasty, ironware was sold globally in a wide geographical range, unlike the former production and consumption pattern that was majorly restricted to China (Chao, 2005). According to the analysis of Ming's political documents, the gradual opening of the Chinese market to the international network was largely promoted by private seaborne trades, of which ironware trade was an essential component (Chao, 2005; Kuhn, 2021). In fact, according to historical documents, iron was one of the essential products being extensively exported to foreign countries including Philippines and Spain (Fan, 2003; Deng, 1997). Hence, in the middle of the Ming Dynasty, ironware started playing the role of strengthening Ming's international economic and cultural contacts across the globe.

## Cultural Significance

As iron production flourished, its symbolic significance started to rise. In the Ming Dynasty, iron was one important ingredient for casting delicate luxury artifacts, a symbol of high social status. One representative of luxury iron artifacts was "Tie Jian Jin," an exquisitely carved and inset artifact, prevalent among the noble families, being used as both decoration and ritual artifact in the Ming Dynasty (Yin, 2023; Liu 2022; Hay, 1995). With outstanding carving and casting techniques, therefore, iron artifacts had come to symbolize royalty and the upper class.

Apart from the cultural significance of iron artifacts, iron production also left a regional cultural signature on certain regions, which had been passed down to the modern Chinese society. The most significant such cultural influence was that some important iron-exporting origins were endowed with regional culture of iron as a signature. For instance, Zunhua city, one of the major iron production sites developed since the Ming Dynasty, is now named "The First Iron Smelting City in China," attracting numerous tourists and historians for its rich iron culture (Qi, 2023; Chen et al., 2016; Wei, 2024). This, on the one hand, reflected the high degree of prosperity in Ming's iron production, of which the large production scale

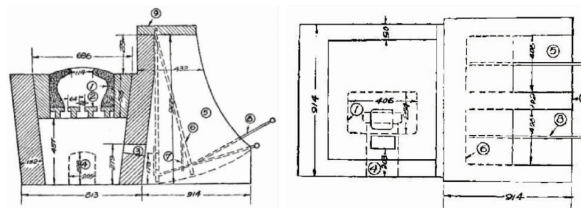
led to the production origin being strongly associated with iron as a cultural symbol; on the other hand, this reflected the long-standing importance of iron starting from Ming society, which penetrated into people's social and cultural lives and was passed down to the modern society.

## Technological Advancements

Along with rapid development, however, there were also challenges that restricted the larger-scaled prosperity of the Ming iron industry. Among these, the most significant factor was technology. Responding to technical difficulties, people in the Ming Dynasty made outstanding efforts. On the one hand, Ming people refined key procedures in iron smelting, thus improving efficiency. Before this refinement, the complex purification process proved to be the greatest culprit limiting iron productivity. The purification in iron production typically played the role of reducing ferric oxide into pure iron through multiple chemical reactions. Inefficiency impacted the quality of the produced iron and slowed production (Qian & Huang, 2021; Wei 2024; Chen et al., 2016). To overcome this difficulty, people in the Ming Dynasty invented the method of shaft furnace smelting, the predecessor of the modern blast furnace, enhancing both production efficiency and iron purity (Huang, 2022). This helped the Chinese iron industry unprecedentedly conquer an important iron production hardship and largely expanded iron productivity.

Apart from the advancements in smelting procedures, the smelting machines also underwent advancements in this period. According to the Ming Dynasty document *Tie Ye Zhi*, which provides important insights into the Ming Dynasty's iron industry, large-scale demand required corresponding growth productivity, which couldn't simply be satisfied by refined smelting methods but required more complex shaft furnace machines (Huang, 2022; Li et al., 2023). Responding to this, Ming-era specialists invented a new kind of smelting equipment, which enhanced forced draft facility to push air down to the reacting furnace to achieve decarbonization, providing more basic reactants such as carbon monoxide and carbon vapor (Jiang et al., 2005). Finer facilities proved to be an important promoter for the Ming Dynasty's iron production and became essential start for later technological developments in the heavy industry.

Figure 2  
Structure of spattering furnace wood fan in Beibei small steelmaking plant in Chongqing



Note. By Zhou Z., 1955. The unit of all numerical values is mm.

## Environmental Challenges

Despite the many outstanding breakthroughs achieved, the iron industry in the Ming Dynasty posed environmental hazards, which was one of the early starts of the human-nature conflicts brought by the heavy industry. According to *Tie Ye Zhi*, large amounts of charcoal were used in iron smelting, meaning that hardwood was consumed extensively (Huang, 2022). This directly led to deforestation and increased natural disasters like sandstorms. According to Ming government records, in 95 years out of the Ming Dynasty's 276-year history, Ming's capital Shuntian Prefecture (today's Beijing) experienced extreme sandstorm disasters, and forests were declining so fast that the government needed to plant artificial protection forests to end overcutting caused by huge charcoal demands (Huang et al., 2016). This was also unprecedented in the sense that the government started artificially preserving nature, which would be imitated by later producers.

## Conclusion

This paper focuses on iron's comprehensive development and influence on Chinese society during the Ming Dynasty. From all aspects including national power, culture, and international communication, the iron industry greatly prospered. However, from the relevant historical records and archaeological discoveries, despite the holistic advancements, there were also emerging challenges in production technologies and environment remaining to be resolved by continued advancements. Upon this literature review of historical development and effects of the Ming Dynasty's iron industry, a thorough as

well as holistic knowledge can be gained from five different social dimensions, compensating for the current shortage of comprehensive studies.

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